Maastricht University

Education and agerelated cognitive decline; the contribution of mental workload.

Citation for published version (APA):

Bosma, J. H. A., van Boxtel, M. P. J., Ponds, R. W. H. M., Houx, P. J., & Jolles, J. (2003). Education and agerelated cognitive decline; the contribution of mental workload. *Educational Gerontology*, *29*(2), 165-173. https://doi.org/10.1080/10715769800300191

Document status and date:
Published: 01/01/2003

DOI:
10.1080/10715769800300191

Document Version:
Publisher's PDF, also known as Version of record

Please check the document version of this publication:

• A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
• The final author version and the galley proof are versions of the publication after peer review.
• The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the “Taverne” license above, please follow below link for the End User Agreement:

www.umlib.nl/taverne-license

Take down policy
If you believe that this document breaches copyright please contact us at:

repository@maastrichtuniversity.nl

providing details and we will investigate your claim.

Download date: 05 May. 2023

Educational Gerontology, 29: 165–173, 2003
Copyright © 2003 Brunner-Routledge
0360-1277/03 $12.00 + .00
DOI:10.1080/03601270390157024

Brunner-Routledge
Taylor & Francis Group

EDUCATION AND AGE-RELATED COGNITIVE DECLINE: THE CONTRIBUTION OF MENTAL WORKLOAD

H. Bosma,
M.P.J. van Boxtel,
R.W.H.M. Ponds,
P.J.H. Houx,
J. Jolles
Maastricht Brain and Behavior Institute,
and European Graduate School of Neuroscience (EURON),
Department of Psychiatry and Neuropsychology,
Maastricht University, Maastricht, Netherlands

Few studies have examined why, in most reports, low education is related to accelerated cognitive decline in middle and old age. Intellectual abilities - whether or not innate - and the mental stimulation provided by the educational process itself are frequently hypothesized to be the most relevant mechanisms. Work characteristics, such as the mental workload of a job, may be another mechanism, as these may also be related to educational level. Moreover, these are more amenable to modification than intellectual abilities. First longitudinal data from the Maastricht Aging Study (MAAS) among 708 men and women aged 50 to 80 in 1993–1995 were used to quantify the contribution of adult mental workload to the association between educational level and age-related cognitive decline. In the 3-year follow-up, persons with a low educational level experienced more decline in cognitive function (information processing speed, memory, and general cognitive function according to the Mini-Mental State Examination) compared to persons with a high educational level. The low prevalence of mental stimuli and challenges at work among the poorly educated subjects explained about 42% of this association. The contribution was independent of crystallized intellectual abilities and was similar across measures of cognitive function. Our findings indicate that the

The study was conducted in close collaboration with the Registration Network Family Practices and related general practitioners. We thank C. Karimoen, M. Kessel, R. Landeweerd, A. Quist, and N. Rozendaal for assistance in medical and neuropsychological testing and constructing the database. This work was supported in part by a grant from the Dutch Ministries of Education and Health and Welfare via the Steering Committee for Gerontological Research (NESTOR).

Address correspondence to Hans Bosma, Maastricht University, P.O. Box 616, Maastricht, 6200 MD, Netherlands. E-mail: hans.bosma@zw.unimaas.nl

gap in the risk of age-related cognitive decline between the poorly and highly educated persons may be substantially narrowed by increasing work-related mental stimuli and challenges among the poorly educated subjects.

Few studies have examined the mechanisms underlying the association between low education and age-related cognitive decline (Lyketsos, Chen, & Anthony, 1999; White et al., 1994). Most advocates of the brain reserve hypothesis have suggested that educational attainment and age-related cognitive decline are related to each other, because both are based on innate or early life cognitive potential (intellectual capacity, brain reserve) (Plassman et al., 1995). Other advocates emphasize that educational experiences per se positively affect brain reserve by providing mental stimuli to pupils (Katzman, 1993). Most studies discussing both explanations refer to the effects of regular education as obtained during childhood and adolescence. Both explanations therefore suggest rather irreversible mechanisms originating in the first two decades of a person's life and determining cognitive decline several decades later. Rather than looking at such early determinants, the present longitudinal study sought to determine and quantify the contribution of a potentially modifiable mechanism operating in adult life, that is, mental demands at work. Mental workload is a likely intermediate factor between educational level and cognitive decline, because persons with a low educational level more often have monotonous jobs with only few mental and cognitive challenges, and because low mental work demands are possibly related to accelerated cognitive decline (Bosma, Van Boxtel, Pond, Houx, & Jolles, 2003; Schooler, Mulatu, & Oates, 1999; Stern et al., 1994). The latter association fits well into the "use-it-or-lose-it" theory (Orrel & Sahakian, 1995; Swaab, 1991). This theory postulates that mental stimuli during adulthood are protective against premature cognitive decline. Evidence for this theory is cumulating (e.g. Christensen et al., 1996; Wilson et al., 2002). Data from the Maastricht Aging Study (MAAS) were used to quantify the contribution of mental workload to the association between educational level and age-related cognitive decline.

PARTICIPANTS

Study Population

The Maastricht Aging Study (MAAS) is a longitudinal study on the determinants of successful aging, particularly with respect to cognitive functioning. Using a registration network of general practices, 9,919 men and women aged 25 to 80 years in the south of The Netherlands (Maastricht and Heerlen) were invited to participate in the baseline study during 1993–1995 (Phase 1). They were without dementia and other medical conditions that are known to interfere with normal cognitive function (e.g., cerebrovascular pathology). There were 3,454 persons who participated in the intensive medical and neuropsychological examination at the university (35% response rate). A subsample of 1,069 men and women aged 50–80 at baseline were again invited to participate in a similar examination at Phase 2 three years later (1996–1998). Due to refusal ($n = 138$), death ($n = 50$), or loss to follow-up ($n = 43$), 838 participants (78%) were actually examined. Our analyses were based on the 708 participants (85%) in this group of whom baseline information was available on mental work demands in the current or last job. Information on working conditions was missing for persons who never had been professionally active (e.g., housewives [$n = 106$]). Further details on the study population can be found elsewhere (Bosma et al., 2003; Jolles, Houx, Van Boxtel, & Ponds, 1995; Van Boxtel et al., 1998).

Cognitive Function

Information processing speed, verbal memory, and general cognitive status were assessed at both baseline and follow-up. The test for information processing speed was based on the Stroop-Color-Word Test. A card displaying one hundred words (all color names) was presented to the participant and the participant's task was to name the hundred words as fast as possible (Stroop, 1935). The time (in seconds) needed to complete the tasks was recorded (Speed). Memory was assessed by the Verbal Learning Test in which the participants were asked to recall as many words as possible directly after the presentation of a list of 15 words (Rey, 1964). There were five trials using the same word list. The total number of words in all five trails was recorded (Memory). The Mini-Mental State Examination (MMSE) was used as an indicator of general cognitive status (Folstein, Folstein, & McHugh, 1975). Higher scores indicate better performance with a maximum of 30 points. Intellectual abilities were measured at baseline with the vocabulary task of the Groningen Intelligence Test (GIT) (Luteijn & Van der Ploeg, 1983). GIT-vocabulary is a multiple-choice test, which can be considered to measure crystallized intelligence, that is, a relatively stable measure of general intellectual ability. The participant is asked to indicate which of five alternative words is synonymous with a given word.

Educational Level and Mental Workload

Attained educational level had seven ordinal categories ranging from primary to university education. Educational level was recoded into three groups: (1) primary education and lower vocational secondary education (low: $n = 327$), (2) intermediate vocational education and general secondary education (intermediate: $n = 223$), and (3) higher vocational education, higher general secondary education, and university (high: $n = 158$). Participants also were asked to describe their job or, if not currently employed, their last job. They were then given a job title code used at Statistics Netherlands. The coding scheme is similar to the U.S. Dictionary of Occupational Titles (U.S. Labor Department, 1991). Information on mental work demands was obtained from an independent survey in which 44,486 employees were asked four questions on mental work demands: (1) Is your work mentally demanding? (2) Do you have to concentrate strongly during work? (3) Does your work require great precision? and (4) Do you regularly work under time pressure? (De Zwart, Broersen, Van Der Beek, Frings-Dresen, & Van Dijk, 1997). Response categories were "no" and "yes." Pearson correlations among the four individual items ranged from 0.58 to 0.92 ($p < 0.01$). The average percentage confirming these questions was computed for each job title code and then matched to the MAAS study using the job title code as the key. The resulting indicator ranged from 13 (low mental workload) to 86 (high mental workload) and was available for 708 participants who had ever been professionally active (with a job title code). Previous research has used similar methods to determine job characteristics (Alfredson, Karasek, & Theorell, 1982; Johnson, Stewart, Hall, Fredlund, & Theorell, 1996). The method is less sensitive to reporting biases that may occur when individual self-reports of work characteristics are used. Further details on these measures can be found elsewhere (Bosma et al., 2003; Jolles et al., 1995; Van Boxtel et al., 1998).

Statistical Analysis

Ordinary least squares regression analysis was used to analyze associations between educational level and cognitive decline during the 3-year follow-up (Phase 2–Phase 1 cognitive functioning). These associations were controlled for age, sex, follow-up interval (mean: 1,149 days; *SD*: 79 days), and cognitive functioning at baseline (Phase 1). The association between educational level and cognitive decline was then separately controlled for mental work demands. The percent decrease of the regression coefficient for educational level was used to quantify the contribution of mental work demands to the association between educational level and cognitive decline. All analyses were also separately controlled for intellectual abilities.

RESULTS

Mental work demands and educational level were positively related (Pearson correlation $+0.60$; $p < 0.01$). Mental work demands also were significantly related to longitudinal cognitive decline. Compared with participants with many mental demands at work (highest third), participants with few demands (lowest third) showed stronger declines in Speed (2.21 seconds more slowing; $p < 0.01$), Memory (2.62 words more decrease; $p < 0.01$), and general cognitive status (0.71 MMSE point more of a decrease; $p < 0.01$).

Low educational level also was related to accelerated cognitive decline during follow-up (Table 1, model 1). During follow-up, participants with a low educational level more strongly decreased in Speed (2 seconds), Memory (2.58 words), and general cognitive status (0.89 MMSE points) than participants with a high educational level. Mental work demands were added in model 2. Coefficients for lower educated participants now decreased to 1.22 (Speed), 1.75 (Memory), and 0.73 (MMSE). A similar substantial decrease was observed when using the continuous measure of education (seven categories) and when the analyses were controlled for (crystallized) intellectual abilities (GIT-vocabulary). In fact, all three associations between educational level and cognitive change lose their statistical significance, when controlled for mental workload and intellectual abilities. The average decrease of the coefficients, after control for mental workload, across all analyses was 42%.

A similar substantial contribution of mental workload to the association between educational level and age-related cognitive decline was found (1) when performing analyses in the separate categories of sex, age, and employment status (currently employed or not), (2) when using alternative subtests for assessing cognitive function and decline, and (3) when dichotomizing the MMSE-score to define possible cognitive impairment or dementia (MMSE < 25). Educational level and mental workload did not interact in their effects on cognitive decline, that is, mental workload had similar effects in the poorly and highly educated participants.

DISCUSSION

Our findings indicate that a substantial part (about 42%) of the association between low educational level and accelerated cognitive

TABLE 1 Association (Unstandardized Regression Coefficients) between Educational Level and Change in Cognitive Functioning, Adjusted for Age, Sex, Length of Follow-Up Interval, and Cognitive Functioning at Baseline (Model 1); Additionally Adjusted for Mental Work Demands (Model 2). Similar Analyses are Presented with Control for Intellectual Abilities [Percent of Education Effect Explained by Mental Work Demands: Percentage Decline of Regression Coefficient of Educational Level, When Mental Workload is Controlled for]

	Educational level				Educational level (controlled for intellectual abilities)			
	Categorical measure				Categorical measure			
	High	Intermediate	Low	Continuous measure	High	Intermediate	Low	Continuous measure
Speed (seconds needed)								
Model 1	Reference[a]	+0.72	+2.00***	+0.46***	Reference	+0.38	+1.26**	+0.29*
Model 2	Reference	+0.45	+1.22*	+0.28*	Reference	+0.15	+0.58	+0.14
		[38]	[39]	[39]		[61]	[54]	[52]
Memory (words recalled)								
Model 1	Reference	−0.44	−2.58***	−0.63***	Reference	−0.12	−1.83**	−0.46***
Model 2	Reference	−0.28	−1.75**	−0.44**	Reference	−0.02	−1.16	−0.31
		[36]	[32]	[30]		[83]	[37]	[33]
MMSE (points obtained)								
Model 1	Reference	−0.34*	−0.89***	−0.20**	Reference	−0.05	−0.26	−0.06
Model 2	Reference	−0.28	−0.73***	−0.16***	Reference	−0.01	−0.17	−0.03
		[18]	[18]	[20]		[80]	[35]	[50]

$^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$.

[a]The high education category is the reference category against which the cognitive change in the intermediate and low education category are contrasted.

decline appears to be mediated by few mental demands at work among poorly educated persons. This indicates that it may prove fruitful to look beyond mechanisms operating in early life or childhood (e.g., intelligence) and predicting cognitive change several decades later. Factors operating in adult life, after the final educational level has been attained, deserve separate attention, as these may be more amenable to modification and intervention. The contribution of mental workload being largely independent of (potentially innate or early) intellectual abilities indicates that mental workload is not just a better proxy for intelligence than education, and further corroborates a "use-it-or-lose-it" perspective on cognitive aging (Swaab, 1991). In fact, the association between educational level and cognitive decline can be fully explained by lower intellectual abilities and a lower mental workload in persons with a low educational level. The process through which mental stimulation at work affects cognitive function may either involve a direct neuro-protective effect, or may involve an additional effect on brain reserve, thereby postponing symptoms of cognitive decline rather than being of significance for underlying pathology (Orrel & Sahakian, 1995). In the latter interpretation, brain reserve may be subject to further change during adulthood, instead of being fully developed in early life and stable thereafter. The findings specifically point to potentially modifiable determinants of unsuccessful cognitive aging, especially in the poorly educated. Monotonous jobs requiring few mental efforts—which are highly prevalent among poorly educated persons—could be enriched by increasing mental challenges in these jobs. Sufficient care should, however, be taken not to overload employees, as this may affect other risk profiles, for example, elevate the risk for cardiovascular disease (Bosma et al., 1997).

Methodological Considerations

Some methodological issues are important. First, several other mechanisms underlying the association between educational level and cognitive decline should be examined in further studies. These include socioeconomic status, socioeconomic background, other occupational hazards, lifestyle factors, social activities, and particular diseases. Secondly, nonresponse was large at baseline and related to old age and low educational level (Jolles et al., 1995). Further selection, also according to low mental work demands, occurred when participants were invited for the follow-up three years later. For example, 74% of the persons with a low educational level participated at Phase 2 (follow-up phase) compared with 83% of their highly educated counterparts.

The former more often refused (16% versus 12%), more often died (5% versus 4%), and more often were lost to follow-up (6% versus 2%). It is therefore likely that the associations of low educational level and low mental work demands with cognitive decline have been underestimated in the present study. It is, however, not clear how this response pattern may have affected the quantification of the contribution of mental workload to the education-cognitive decline association. Finally, our indicator of mental work demands may have some shortcomings. Information on mental workload was largely based on data from an independent source.While reducing any reporting bias, actual differences in mental work demands between workers within the same job title code are lost using this information. Furthermore, using this job exposure method, housewives were excluded from the analyses, when they never had been professionally active (with a job title code). Therefore, we cannot determine the mental load of household tasks and raising children and its relevance for cognitive aging.

CONCLUSION

A substantial part of the association between low educational level and accelerated cognitive decline appears to be mediated by few mental demands at work among the poorly educated participants. This indicates that the gap in the risk of age-related cognitive decline between poorly and highly educated persons may be substantially narrowed by increasing work-related mental stimuli and challenges among the poorly educated participants.

REFERENCES

Alfredsson, L., Karasek, R., & Theorell, T. (1982). Myocardial infarction risk and psychosocial work environment: An analysis of the male Swedish working force. *Social Science and Medicine, 16*, 463–467.

Bosma, H., Marmot, M. G., Hemingway, H., Nicholson, A. C., Brunner, E., & Stansfeld S. A. (1997). Low job control and risk of coronary heart disease in Whitehall II (prospective cohort) study. *British Medical Journal, 314*, 558–565.

Bosma, H., Van Boxtel, M., Ponds, R., Houx, P., & Jolles, J. (2003). Mental work demands protect against cognitive impairment: MAAS prospective cohort study. *Experimental Aging Research, 29*, 33–45.

Christensen, H., Korten, A. E., Jorm, A. F., Henderson, A. S., Scott, R., & Mackinnon, A. J. (1996). Activity levels and cognitive functioning in an elderly community sample. *Age and Ageing, 25*, 72–80.

De Zwart, B., Broersen, J., Van der Beek, A., Frings-Dresen, M., & Van Dijk, F. (1997). Occupational classification according to work demands: An evaluation study. *International Journal of Occupational Medicine and Environmental Health, 10*, 283–295.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). 'Mini-Mental State:' A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12*, 189–198.

Johnson, J. V., Stewart, W., Hall, E. M., Fredlund, P., & Theorell, T. (1996). Long-term psychosocial work environment and cardiovascular mortality among Swedish men. *American Journal of Public Health, 86*, 324–331.

Jolles, J., Houx, P. J., Van Boxtel, M. P. J., & Ponds, R. W. H. M. (1995). *Maastricht aging study: Determinants of cognitive aging*. Maastricht: Neuropsych.

Katzman, R. (1993). Education and the prevalence of dementia and Alzheimer's disease. *Neurology, 43*, 13–20.

Luteijn, F., Van der Ploeg, F. A. E. (1983). *Handleiding Groninger Intelligentietest (GIT)*. Lisse: Swets and Zeit-linger.

Lyketsos, C. G., Chen, L., & Anthony, J. C. (1999). Cognitive decline in adulthood: An 11.5-year follow-up of the Baltimore Epidemiologic Catchment Area Study. *American Journal of Psychiatry, 156*, 58–65.

Orrel, M., & Sahakian, B. (1995). Education and dementia. Research evidence supports the concept "use it or lose it." *British Medical Journal, 310*, 951–952.

Plassman, B. L., Welsh, K. A., Helms, M., Brandt, J., Page, W. F., & Breitner, J. C. S. (1995). Intelligence and education as predictors of cognitive state in late life: A 50-year follow-up. *Neurology, 45*, 1446–1450.

Rey, A. (1964). *L'examen psychologique dans les cas d'encepholopathie traumatique*. Paris: Presses Universi-taires de France.

Schooler, C., Mulatu, M. S., & Oates, G. (1999). The continuing effects of substantively complex work on the intellectual functioning of older workers. *Psychology of Aging, 14*, 483–506.

Stern, Y., Gurland, B., Tatemichi, T. K., Tang, M. X., Wilder, D., & Mayeux, R. (1994). Influence of education and occupation on the incidence of Alzheimer's disease. *Journal of the American Medical Association, 271*, 1004–1010.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*, 643–662.

Swaab, D. F. (1991). Brain aging and Alzheimer's disease. "Wear and tear" versus "Use it or lose it." *Neurobiology of Aging, 12*, 317–324.

U.S. Labor Department (1991). *Dictionary of occupational titles* (4th ed.). Washington, DC: Autj

Van Boxtel, M. P. J., Buntinx, F., Houx, P. J., Metsemakers, J. F. M., Knottnerus, A., & Jolles, J. (1998). The relation between morbidity and cognitive performance in a normal aging population. *Journals of Gerontology, Medical Sciences, 53A*, 147–154.

White, L., Katzman, R., Losonczy, K., Salive, M., Wallace, R., Berkman, L., Taylor, J., Fillenbaum, G., Harlik, R. (1994). Association of education with incidence of cognitive impairment in three established populations for epidemiologic studies of the elderly. *Journal of Clinical Epidemiology, 47*, 363–374.

Wilson, R. S., Mendes De Leon, C. F., Barnes, L. L., Schneider, J. A., Bienias, J. L., Evans, D. A., Bennett, D. A. (2002). Participation in cognitively stimulating activities and risk of incident Alzheimer disease. *Journal of the American Medical Association, 287*, 742–748.